Eliminating the Operator Control Unit

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Towards a Warfighter's Associate: Eliminating the Operator Control Unit

Outline

Introduction

Technical Challenges

Natural Language Understanding

Effecting the Desired Control

Autonomous Behaviors

Report Documentation Page

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Introduction

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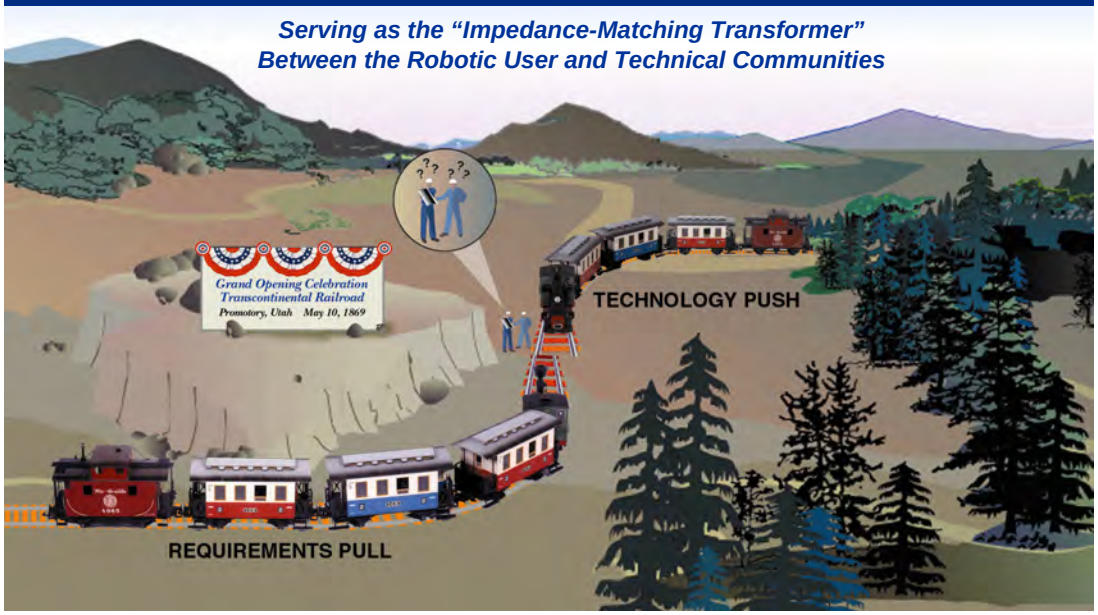

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Introduction

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- About 200 man-portable robots deployed in-theatre
  - Foster Miller *Talons*
  - iRobot *Packbots*
  - Mesa *Matildas*
  - Remotec *Mini-Andros*
  - EOD Performance Inc. *Vanguards*
- Missions
  - Explosive ordnance disposal (EOD)
  - Scouting unsecured bunkers, buildings, caves

ALL ARE STRICTLY TELE-OPERATED

ALL HAVE PROPRIETARY VENDOR-SPECIFIC OCUs

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- A significant performance trade-off exists
  - How well do the robots assist users in performing their jobs?
  - How much does the OCU interfere with the users' abilities to perform/survive?
- Solution
  - Make robots more functional with greater autonomy
  - Minimize or eliminate the OCU
  - Make robots more desirable for alternative tasks

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Introduction

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- **Near Term Goal: Provide a Common OCU**
  - Simplifies training and logistics support
  - Promotes interoperability
- **Long Term Goal: Completely Eliminate the OCU**
  - Ongoing development efforts to equip warfighter with Voice-Over-IP technologies:
    - Land Warrior, Raytheon Systems Company
    - Advanced Robotic Controller (ARC), Exponent
    - Others
  - Supports bi-directional audio, video, maps
  - This same HW provides all that is required to control the robot

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WARFIGHTER'S ASSOCIATE CONCEPT

- Sophisticated robotic system
- Accompany warfigher during mission execution
- Synergistic teaming of human and machine
- Uses existing communications equipment
- No dedicated OCU required

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SYNERGISTIC HUMAN-MACHINE TEAMING

Human Characteristics	Machine Characteristics
Extremely Adaptive	More Robust
Very Perceptive	Fearless
Capable of Reasoning	Process/Analyze Large Amounts of Data
Amazingly Flexible	Expendable

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ENVISIONED ROLES OF WARFIGHTERS ASSOCIATE

- Complement and safeguard the human partner
- Handle any high-risk tasks
- Perform mundane and tedious tasks
- Serve as subject matter expert on demand
  - Field interpret/translate foreign language
  - Provide repair/maintenance instructions
  - Oversee field medical procedures
  - With internet access, provide limitless knowledgebase

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CONCEPT DEVELOPMENT PLATFORM

- Leveraging existing laboratory prototype
- Sophisticated navigation, collision avoidance, mapping, and surveillance schemes
- 90-amp-hour battery
- Extensive self diagnostics
- Size compatible with SICK laser

ROBART III

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Technical Challenges

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- **Mobility**
  - Many different options (wheels, tracks, legs)
  - Other development efforts addressing this issue
- **Navigation**
  - Localization & collision avoidance
  - Fairly robust solutions currently available
- **Power**
  - Improved power sources will be required
  - Other efforts addressing this issue
- **Command & Control**
  - Need to reduce operator control burden
  - Major thrust of our effort

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Command & Control

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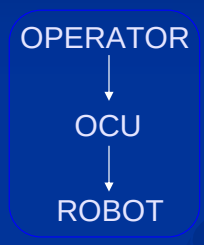
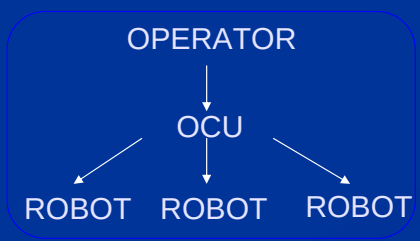
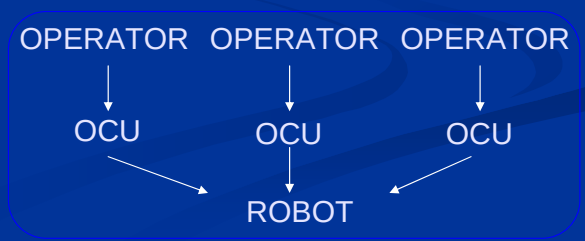
In the beginning, there was a one-to-one correspondence between the robot and some dedicated controller



This is evolving to multi-robot, multi-operator complexities





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Command & Control

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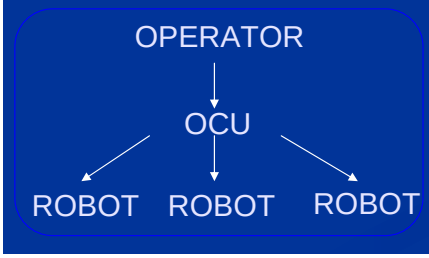
- Eliminated prior one-to-one robot/CPU association
- Allowed multiple robot control including robots of different types

MDARS Multiple-Resource Host Architecture



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Common OCU

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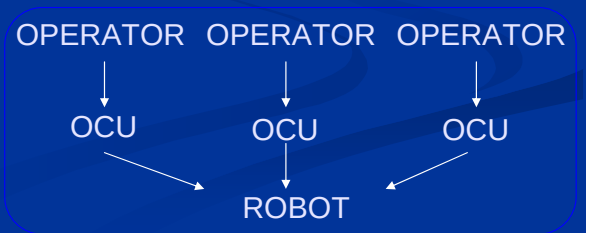
SSC-SD's Common OCU, which runs the Multi-Robot Operator Control Unit (MOCU)

- One operator can control multiple robots as with MRHA
- Multiple operators can now control same robot
- Will support handoff from team to team
- Plug-n-play modular I/O



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Common OCU Hardware

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- Handheld unit

Top

Snap-on Controller

Bottom

Features:

- Common Display Unit
- Snap-on controllers (left and right)
- 6.4" Sunlight readable display
- Real-time video display
- Robot status display w/ gauges

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Sample OCU

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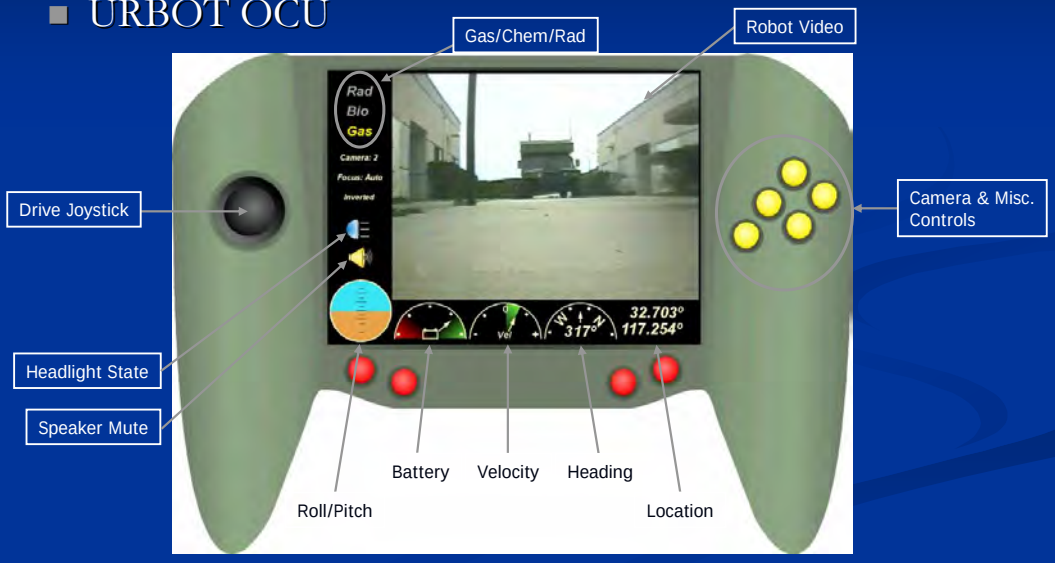
- URBOT OCU



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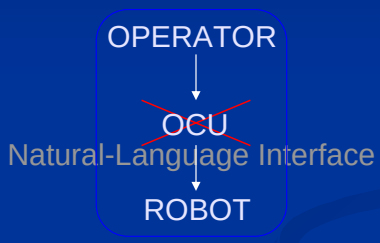
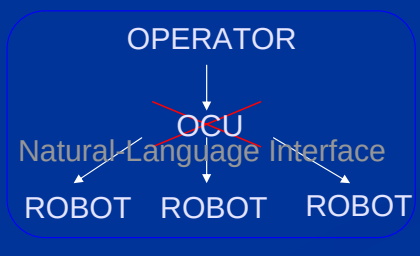
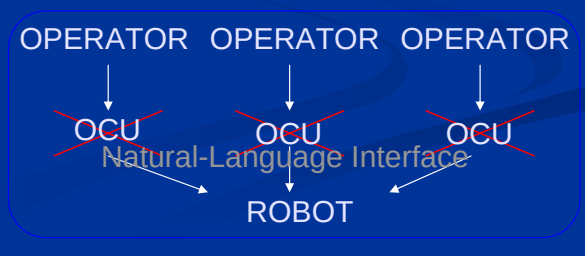
Command & Control

LONG TERM GOAL: ELIMINATE OCU ALTOGETHER







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Natural Language Interface

Bidirectional Voice I/O Requirement

- Generate speech (speech synthesis)
  - Very mature technology
  - Unlimited vocabulary
- Understand speech
  - Recognize spoken words
  - Parse resultant text
  - More difficult to do

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Voice Recognition

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- Recognition Algorithm: Incoming Speech ⟶ Text String
- Commercial Voice-Recognition
  - Exploits high signal-to-noise ratio w.r.t. incoming audio stream
  - Speak directly into a boom mike/telephone mouthpiece
  - Pre-taught voice signatures
- Battlefield Environment
  - Much noisier unstructured environment
  - Increase in voice pitch, speed, volume when under stress

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Voice Recognition

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- Bone-conduction Headsets
  - Microphone as well as earphones
  - Acoustically coupled with the bone structure of the skull
- *Jawbone*
  - Two audio microphones
  - Bone-conduction sensor
  - DSP to subtract background noise

Jawbone

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Text Parsing

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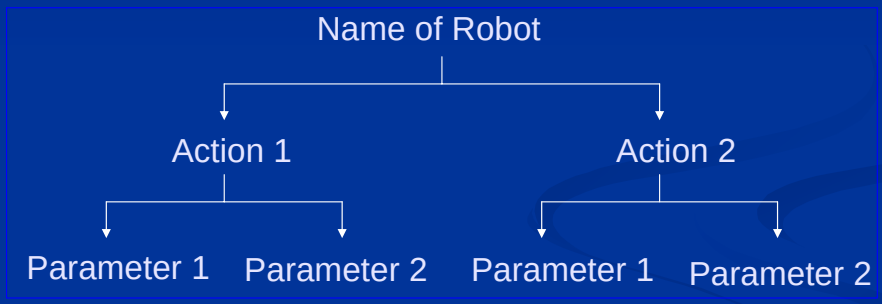
- SIMPLISTIC CASE: Translating structured text string into a command using layered-menu conditional-branching approach



- MORE DIFFICULT CASE*:* Parsing lengthy unstructured text
- WARFIGHTER'S ASSOCIATE: Needs are in the middle
  - Semi-structured text
  - Fairly short phrases

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Text Parsing

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- Developed prototype unstructured text parser
  - Accepts dictated or typed text input
  - Email interface allows independent development
    - – Decouples speech-recognition errors
    - – Provides useful robot-human interface

ROBART III

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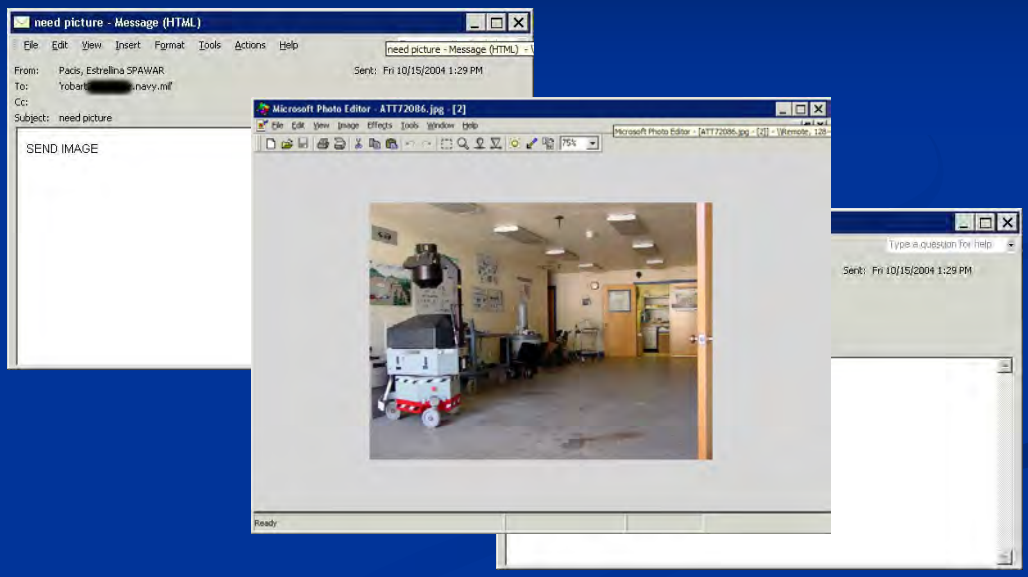
Email Interface



Email sent to and received from *ROBART III* requesting an image.

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Effecting the Desired Control

Requires some common frame of reference

to which both human & robot can relate

- Robo-Centric – Relative to robot itself
- Vision-Centric – Relative to robot's camera view
- Model-Centric – Relative to absolute world model

COMBINATION OF THESE APPROACHES PROVIDES THE MOST FLEXIBILITY

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Robo-Centric Reference

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- Relative to robot itself
  - Send low-level motion commands (turn left, right)
  - Initiate sensor-assisted motion (follow the wall to the left)
- Control camera gaze (pan left, pan right)
- Too restrictive and operator intensive in general

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Vision-Centric Reference

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- Relative to robot's camera view
- Operator looking at video feedback
  - Provides direction based on common video image
  - "Enter doorway in front of you"
  - Vision system looks for and highlights doorway
- Can also illuminate attributes of interest with laser pointer

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Vision-Centric Reference

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- Very appropriate for high-level weapon control
  - Database of targets and their vulnerabilities
  - Search-and-destroy:
    - Identifies object
    - Zooms in on vulnerability
    - Non-lethal weapon cued

Search Algorithm on *ROBART III*

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Model-Centric Reference

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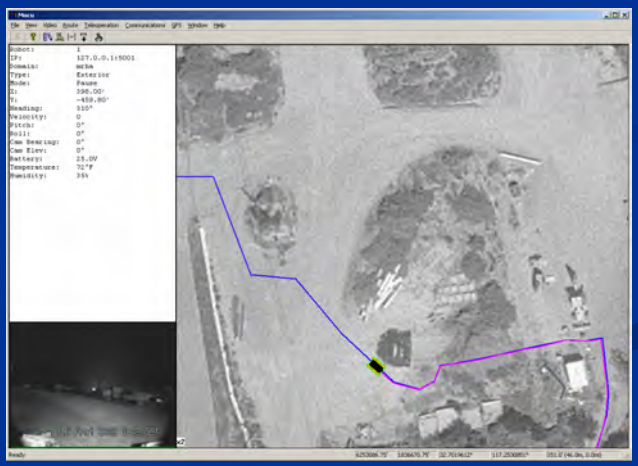
- Relative to an absolute world model
- Outdoors – GPS
  - *MOCU*
  - Operator draws desired route
  - Alternatively selects waypoints or goal destination



MOCU Display

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Model-Centric Reference

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- Indoors – GPS not available
  - Must localize using range data from surroundings
  - *MDARS-I* had a priori map
    - Executes virtual paths to predefined nodes
    - Not practical in tactical applications

MDARS-I patrolling Camp Elliot Warehouse in 1995.

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Model-Centric Reference

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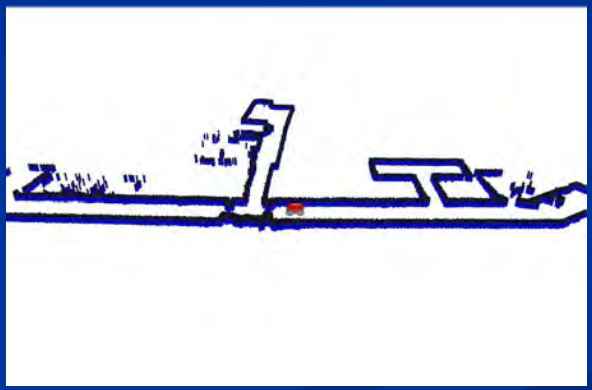
- SRI International
  - No a priori knowledge
  - SLAM
- INEEL
  - Collision Avoidance
  - Grow to "3D" representation
  - Awkward to send coordinates (i.e., go to 1200, 3250)



Autonomously exploring Battery Woodward (an underground WWII bunker) at SSC-SD

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Model-Centric Reference

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Reality-Virtuality Continuum as proposed by Milgram

Real Environment – Robot's video feedback

Virtual Environment – Represented by SLAM model

Augmented Reality – Link additional info to video image as pop-up overlay

Augmented Virtuality – Link additional info from other sensors (or from operator) to SLAM model

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Model-Centric Reference

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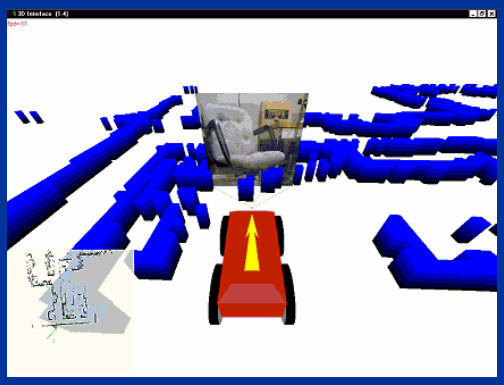
Augmented Virtuality – link additional sensor info to SLAM model



Virtual model fused with video image input from video sensor onboard the exploring robot.

Virtual model fused with room identification tags from operator input.

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Providing high-level (natural-language) direction implies the robot must be able to execute high-level autonomous behaviors.

- What do we have working now?
- What are we going to do next?
- What's further down the road?

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Autonomous Behaviors

Working Now:

- Basic/high-level mobility commands
- Explore & map structure
- Building sweep
- Surveillance
- Motion detection
- Target following video
- Weapon control
- Convoy capability video
- Progressive sleep mode
- Automated recharging or refueling
- Self diagnostics
- Send/receive email with attachments

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Autonomous Behaviors

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Focus in FY-05:

- Simplistic sign interpretation
- GPS waypoint navigation
- Visual landmark homing
- Motion detection-on-the-move

SSC-SD

Perceptek

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Autonomous Behaviors

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Investigating further down the road:

- Complex sign interpretation
- Face recognition
- License-plate capture
- Foreign-language interpretation

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Conclusion

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- Need more autonomous robotic functionalities
  - Technology Transfer program improves functionality and autonomy of candidate platforms.
- Need to lessen control burden on operator by minimizing/eliminating the OCU
  - Common OCU (standardized, modular, plug-n-play)
  - Natural-language interface
  - Common frame of reference incorporating robot-, vision-, and model-centric
  - Expansion of SLAM model for augmented-virtuality